

## Chem 20A Final Exam, Winter 2018

Name \_\_\_\_\_

ID: \_\_\_\_\_

Please note: your grade will be based on the best 5 questions you answer! You can pick just five questions to answer, or if you answer all six we will grade you based on the best 5 out of these six.

Some Physical Constants:

$$h(\text{Planck constant}) = 6.63 \times 10^{-34} \text{ J} \cdot \text{s} = 4.14 \times 10^{-15} \text{ eV} \cdot \text{s}$$

$$c(\text{velocity of light}) = 3 \times 10^8 \text{ m/s}$$

$$1 \text{ eV} = 1.602 \times 10^{-19} \text{ J}$$

$$N_A(\text{Avogadro's constant}) = 6.02 \times 10^{23} \text{ mol}^{-1}$$

$$m_e(\text{mass of electron}) = 9.1 \times 10^{-31} \text{ kg}$$

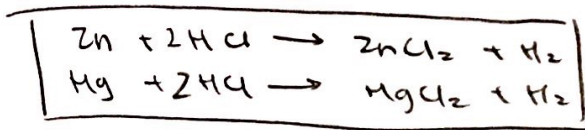
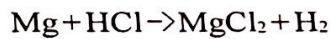
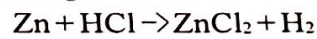
$$1 \text{ Rydberg} = 13.6 \text{ eV} = 2.18 \times 10^{-18} \text{ J}$$

$$a_0(\text{Bohr radius}) = 0.53 \text{ \AA}$$

$$1 \text{ \AA} = 10^{-10} \text{ m}$$

Question	Points	Maximum
1	20	20
2	10	20
3	17	20
4	16	20
5	13	20
6	19	20
Best 5 total		100

a) Balance the equations for the following reactions



10 ✓

b) A 5.0 g mixture of Zn and Mg is dissolved in aqueous HCl to produce 0.2585 g of hydrogen gas  $\text{H}_2$ . What is the percent of Zn by mass in the mixture?

$$\begin{aligned} & \left( A \text{ g Zn} \times \frac{1 \text{ mol Zn}}{65.409 \text{ g Zn}} \times \frac{1 \text{ mol H}_2}{1 \text{ mol Zn}} \times \frac{2.016 \text{ g H}_2}{1 \text{ mol H}_2} \right) \\ & + \left( [5-A] \text{ g Mg} \times \frac{1 \text{ mol Mg}}{24.305 \text{ g Mg}} \times \frac{1 \text{ mol H}_2}{1 \text{ mol Mg}} \times \frac{2.016 \text{ g H}_2}{1 \text{ mol H}_2} \right) = 0.2585 \text{ g H}_2 \end{aligned}$$

$$\frac{2.016}{65.409} A + \frac{5(2.016)}{24.305} - \frac{2.016}{24.305} A = 0.2585 \text{ g H}_2$$

$$A \left( \frac{2.016}{65.409} - \frac{2.016}{24.305} \right) = 0.2585 - \frac{5(2.016)}{24.305}$$

$$A = \frac{0.2585 - \frac{5(2.016)}{24.305}}{\frac{2.016}{65.409} - \frac{2.016}{24.305}}$$

$$= 2.9972 \text{ g Zn}$$

$$\frac{2.9972 \text{ g Zn}}{5 \text{ g Zn} + \text{Mg}} \times 100\% = \boxed{59.94\%}$$

2. a) Using Bohr model, give an estimate of the volume of a hydrogen atom in its ground state. Bohr radius  $a_0$ . Then estimate its volume by plugging numbers into your formula when electron is moving in its ground state ( $n=1$ ). Write your final answer in terms of angstrom cubed ( $1 \text{ \AA} = 10^{-10} \text{ m}$ ).

$$V = \frac{4}{3} \pi r^3$$

$$r = \frac{n^2}{Z} a_0$$

$$V = \frac{4}{3} \pi \left( \frac{n^2}{Z} a_0 \right)^3 \quad Z=1$$

$$V = \frac{4}{3} \pi n^6 a_0^3$$

$$V = \frac{4}{3} \pi a_0^3 \quad n=1$$

$$= \frac{4}{3} \pi (0.529 \text{ \AA})^3$$

$$= 1.62 \text{ \AA}^3$$

10

b) Now let's assume that electron is 1000 times heavier than what it really is. Would this change the volume of an H atom, and by how much. Be very careful in answering this question!

This would not change the volume of the H atom because the formula for volume  $[V = \frac{4}{3} \pi n^6 a_0^3]$  does not show that it is proportional to the mass of an electron in any way.

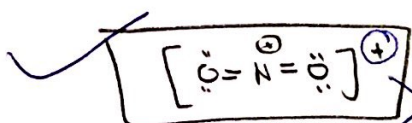
X

ID: EXO

3.

a) Draw the lewis structure of  $\text{NO}_2^+$

$$5 + 2(4) - 1 = 16 \text{ val}^-$$



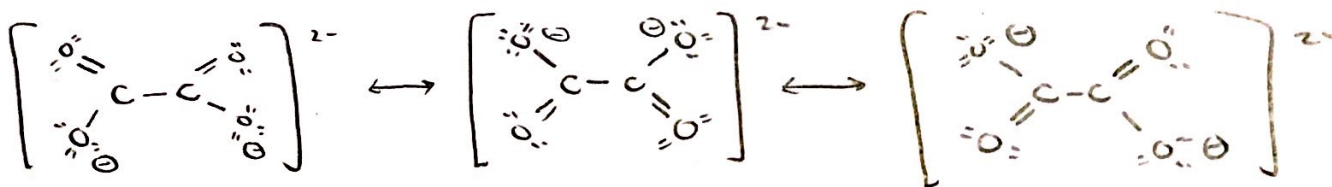
$$\text{O} = 6 - 4 - \frac{1}{2}(4) = 0$$

$$\text{N} = 5 - 0 - \frac{1}{2}(8) = 1$$

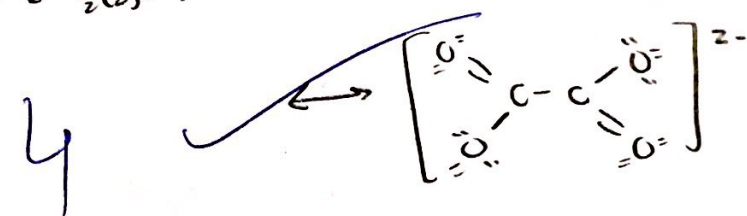
only one to be shown

b) Draw the lewis structure and all resonance structures of  $\text{C}_2\text{O}_4^{2-}$  (Hint: the carbons are the central atoms and the oxygens are attached to them)

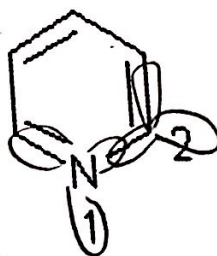
$$2(4) + 4(6) + 2 = 34 \text{ val}^-$$



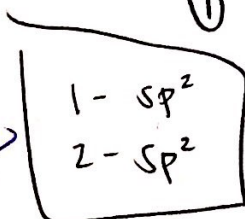
$$\text{O} = 6 - 6 - \frac{1}{2}(2) = -1$$



c) What are the hybridizations of atoms 1 and 2 respectively in the following structure?

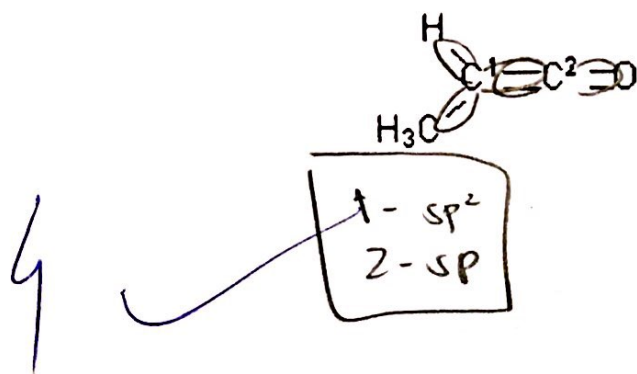


4 ✓

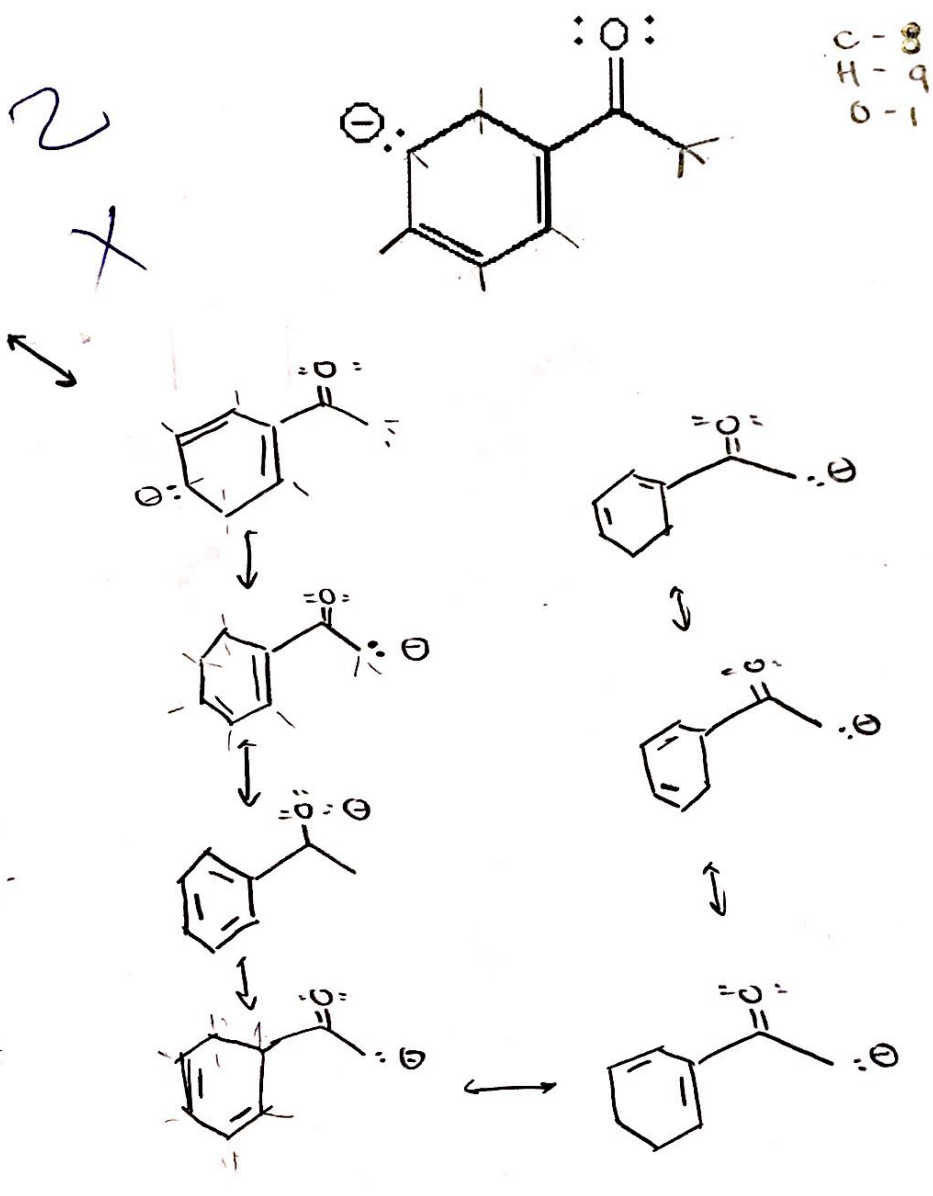


ID: \_\_\_\_\_

d) What are the hybridizations of atoms 1 and 2 respectively in the following structure?



e) Draw all the other resonance structures of the following species.



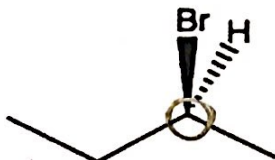
ID:

4.

Circle all the chiral carbons (if any) in the following molecules. Draw all their stereoisomers if there are any.

a)

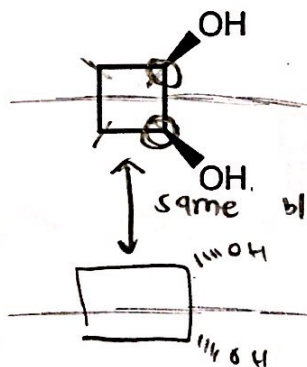
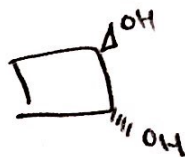
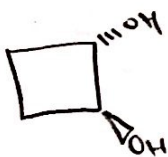
$2^1 \rightarrow 2$  stereoisomers max



3

b)

$2^n \rightarrow 4$  max stereoisomers

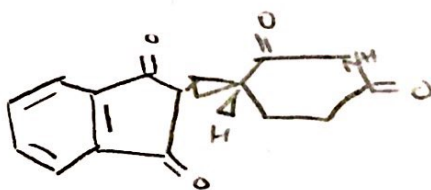
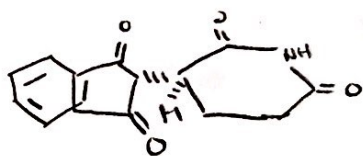
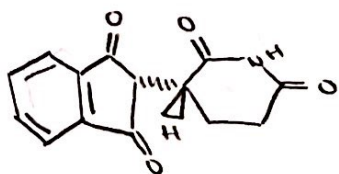
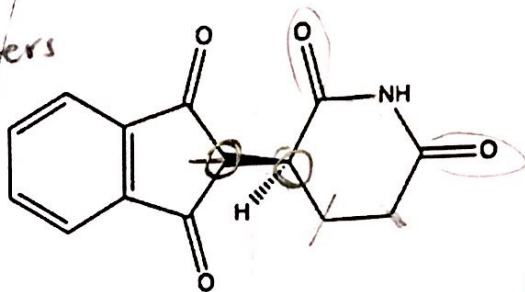


4

ID:

c)

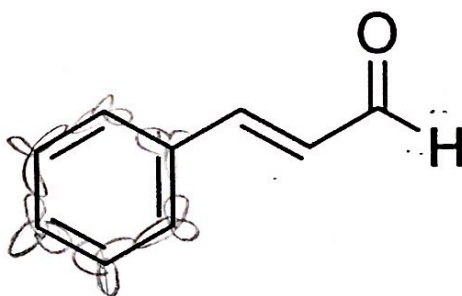
$2^2 \rightarrow$  max 4 stereoisomers



d)

none

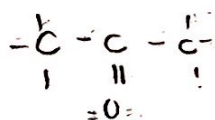
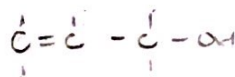
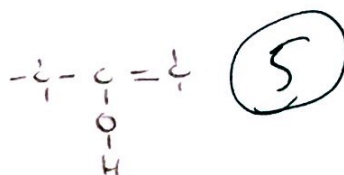
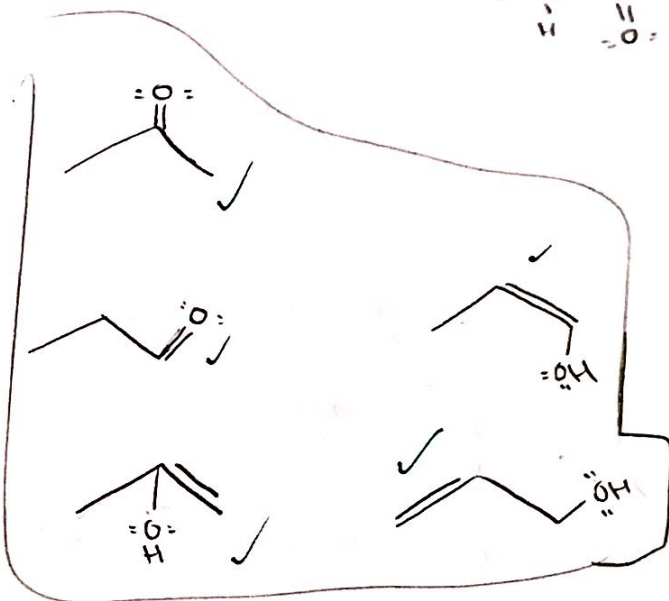
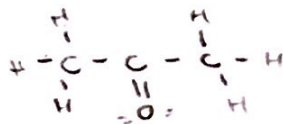
2



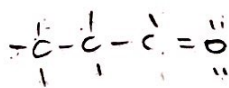
ID: \_\_\_\_\_

e) Draw 5 isomers with molecular formula  $C_3H_6O$

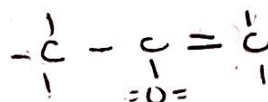
$$3(4) + 6(1) + 6 = 24 \text{ ve's} \quad 12 \text{ bonds (pr)}$$



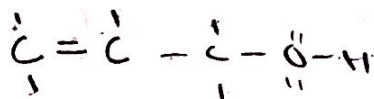
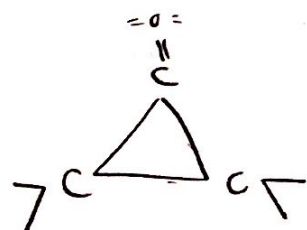
C 3  
H 6  
O 1  
ve 24



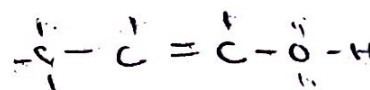
C 3  
H 6  
O 1  
ve 24



ve 24  
H 6  
C 3  
O 1



6H  
3C  
1O  
12b



6H  
3C  
1O  
12b

a) It is known that the transition metal complex  $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$  has the crystal field energy-level diagram for the complex, labeling the d-orbitals. Predict whether the complex is diamagnetic or paramagnetic. Explain your answers.

Because the complex has isomerism, <sup>it has 4 ligands</sup> the complex is a tetrahedral. If it were square planar, isomers would not be possible.

$\text{NH}_3 \rightarrow$  intermediate  
 $\text{Cl} \rightarrow$  weak

$\text{NH}_3 \rightarrow 0$   
 $\text{Cl} \rightarrow -1 \Rightarrow -2$

$\text{Pt} = 2+$

$\text{Pt} : s^2 d^7$

$\text{Pt}^{2+} : d^7$

$\frac{1}{d_{x^2}} \quad \frac{1}{d_{xy}} \quad \frac{1}{d_{yz}}$

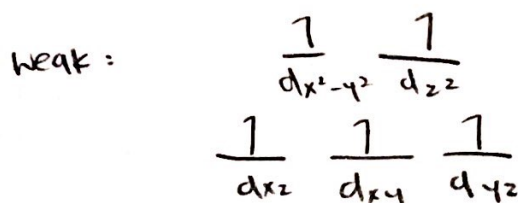
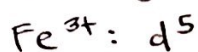
$\uparrow\downarrow \quad \uparrow\downarrow$   
 $d_{x^2-y^2} \quad d_{z^2}$

complex is paramagnetic because the complex has 3 unpaired electrons.

(3)

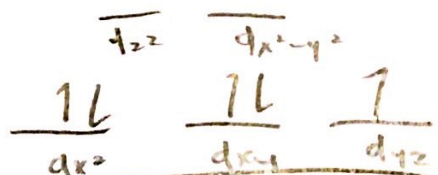
ID:

b) Draw the crystal field splitting diagrams in octahedral field for  $\text{Fe}^{3+}$  and  $\text{Mn}^{2+}$ , show orbital occupancies in both weak and strong octahedral fields, and calculate the number of unpaired electrons



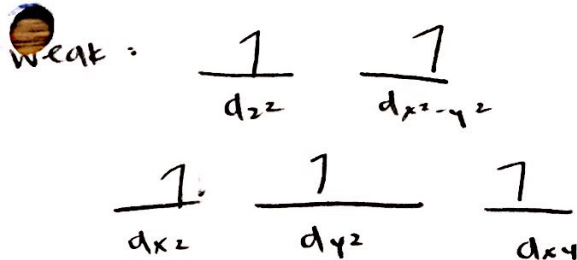
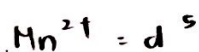
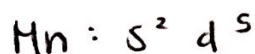
5 unpaired  $e^-$ 's

strong:



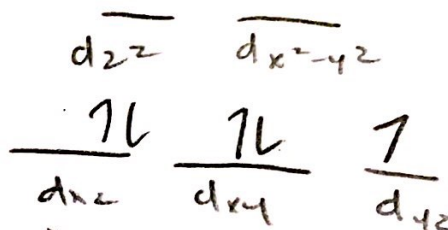
1 unpaired  $e^-$

10



5 unpaired  $e^-$ 's

strong:

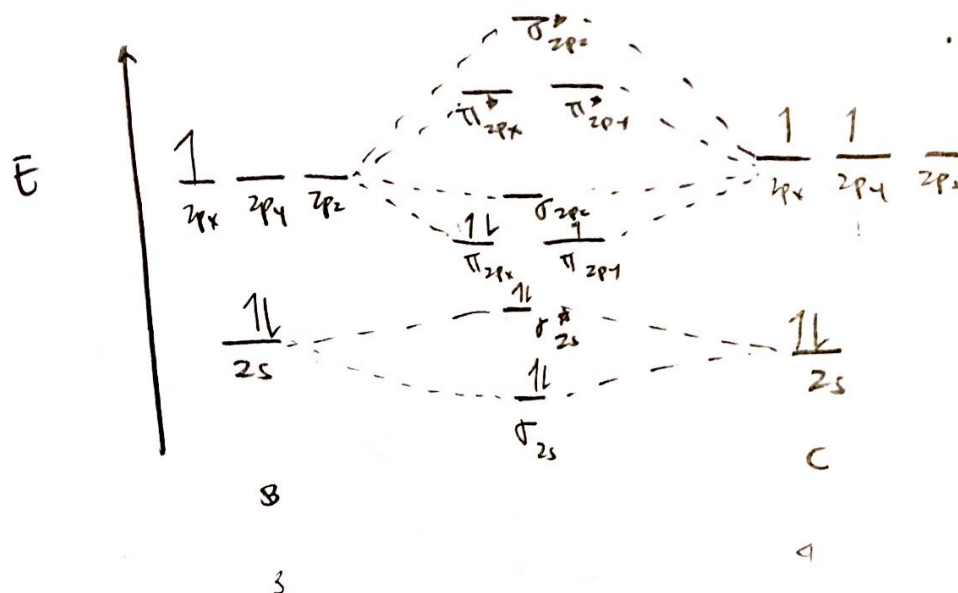


1 unpaired  $e^-$

ID: \_\_\_\_\_

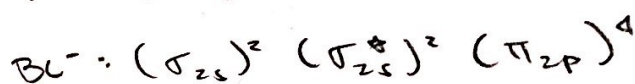
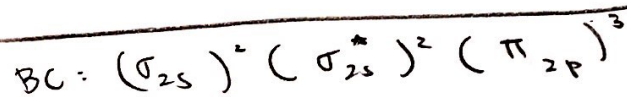
6.

a) Draw a MO diagram for the valence electrons of BC. Label all atomic and molecular orbitals.



6

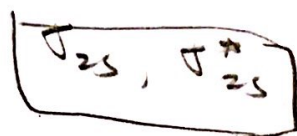
b) Write the molecular orbital configuration for the valence electrons in BC and in  $BC^-$ .



4

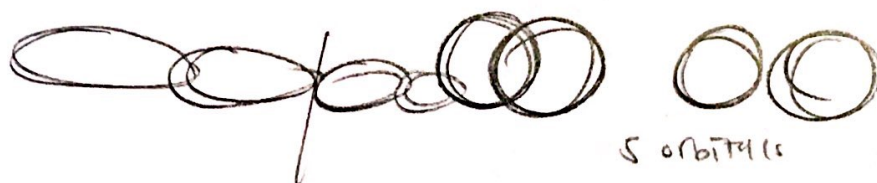
ID:

c) Which of the molecular orbitals in BC do not have a planar node along the internuclear axis?



radial node

4



d) Which of the three has the strongest B-C bond,  $BC^+$ , BC or  $BC^-$ ? Justify your answer using bond order.

$$BC^+ : (\sigma_{2s})^2 (\sigma_{2s}^*)^2 (\pi_{2p})^2 \rightarrow BO = \frac{1}{2}(4-2) = 1$$

$$BC : (\sigma_{2s})^2 (\sigma_{2s}^*)^2 (\pi_{2p})^3 \rightarrow BO = \frac{1}{2}(5-2) = 1.5$$

$$BC^- : (\sigma_{2s})^2 (\sigma_{2s}^*)^2 (\pi_{2p})^4 \rightarrow BO = \frac{1}{2}(6-2) = 2$$

$BC^-$  has the strongest B-C bond because its bond order is the highest of the 3.

5